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(54) **SELF-HEALING REPEATER NODE**

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398/177; 398/181; 359/341.3

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398/97, 45, 6, 13, 20, 28, 33, 82, 94, 49,
398/50, 51, 54, 56, 173, 175, 177, 180, 181,
398/21; 359/341.3, 341.33

See application file for complete search history.

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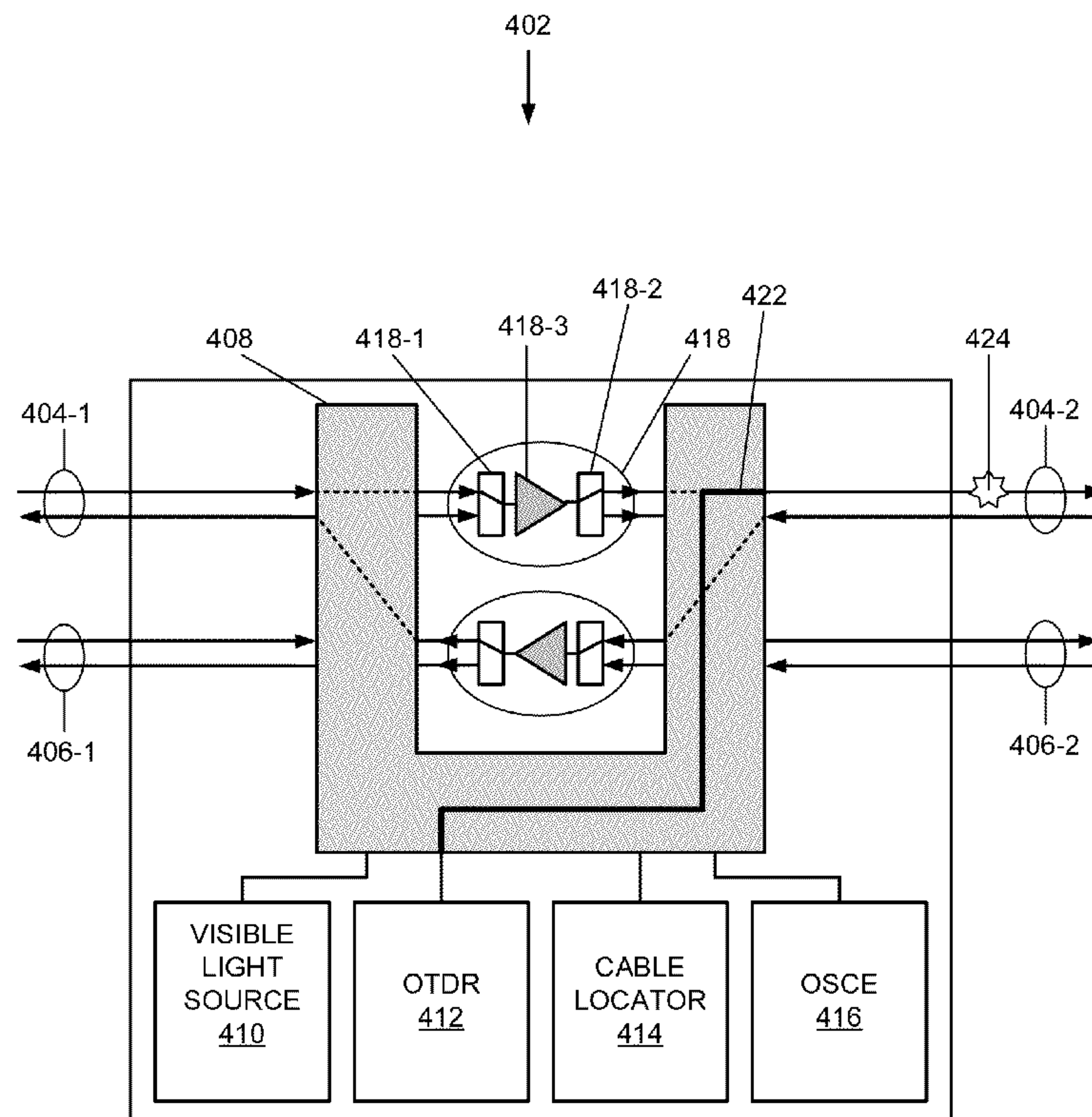
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Primary Examiner — M. R. Sedighian

(57) **ABSTRACT**

A device may include a component, a first switch, a repeater, and a second switch. The component may configure optical paths between ports. The component may comprise a first pair of optical ports connected to a first pair of optical fibers, and a second pair of optical ports connected to a second pair of optical fibers. The first switch may be configured to output one of two optical signals received by the first pair of optical ports from the first pair of optical fibers. The repeater may reshape or amplify the outputted optical signal. The second switch may be configured to direct the reshaped or amplified signal to one of the second pair of optical ports.

12 Claims, 7 Drawing Sheets



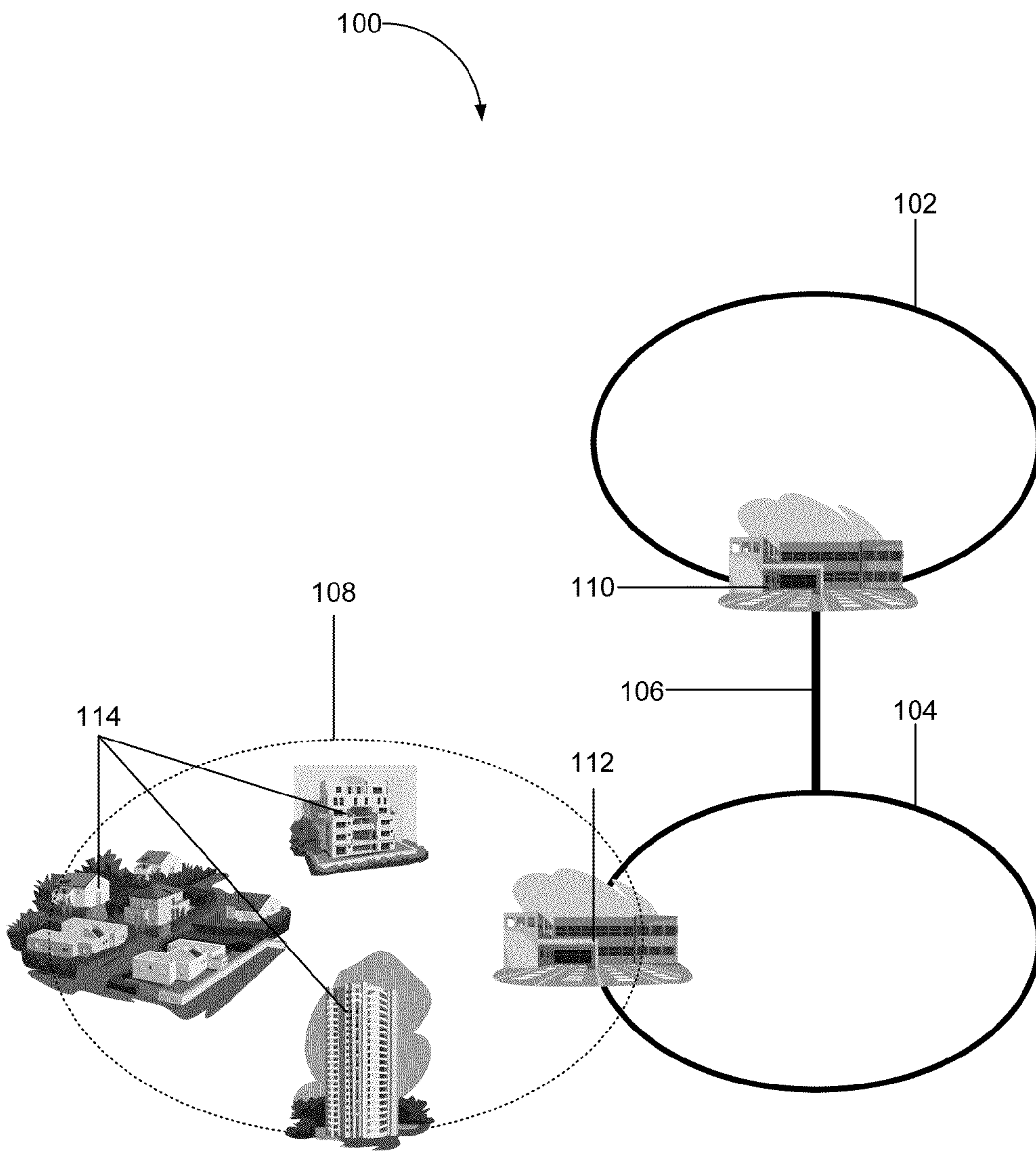


Fig. 1

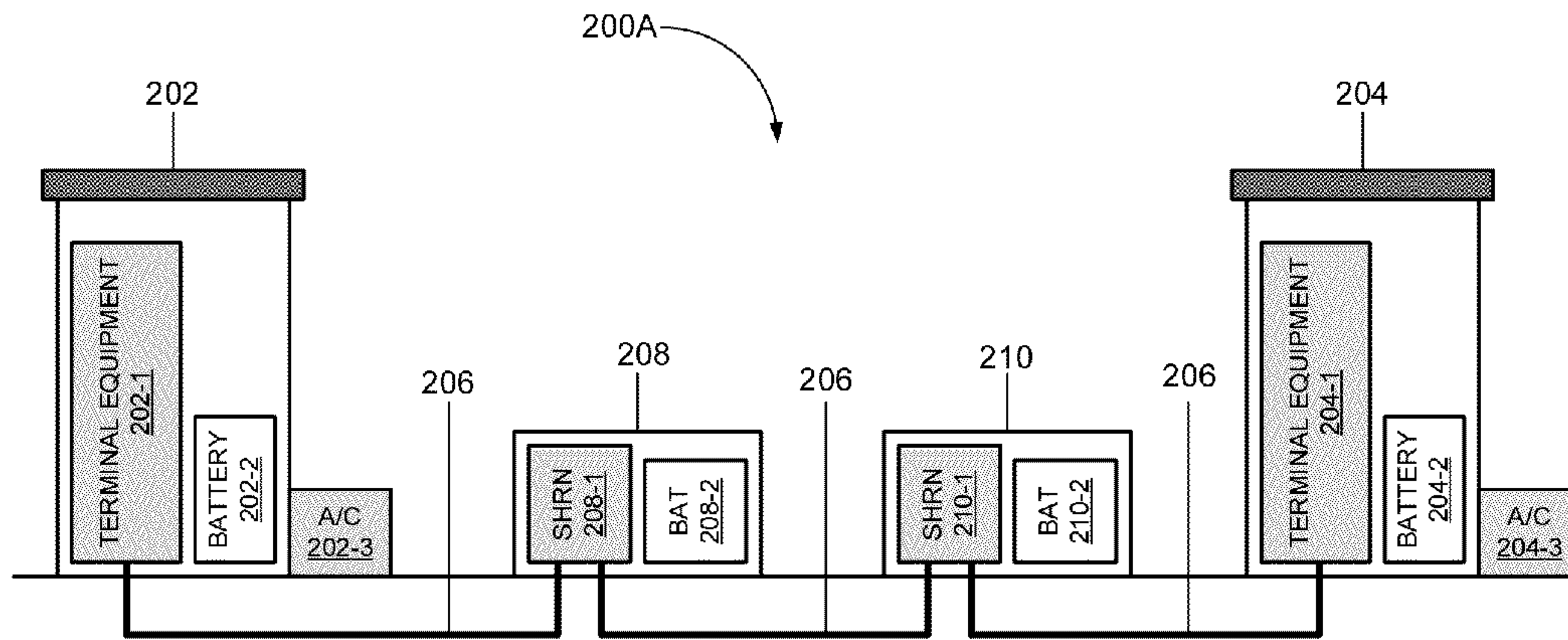


Fig. 2A

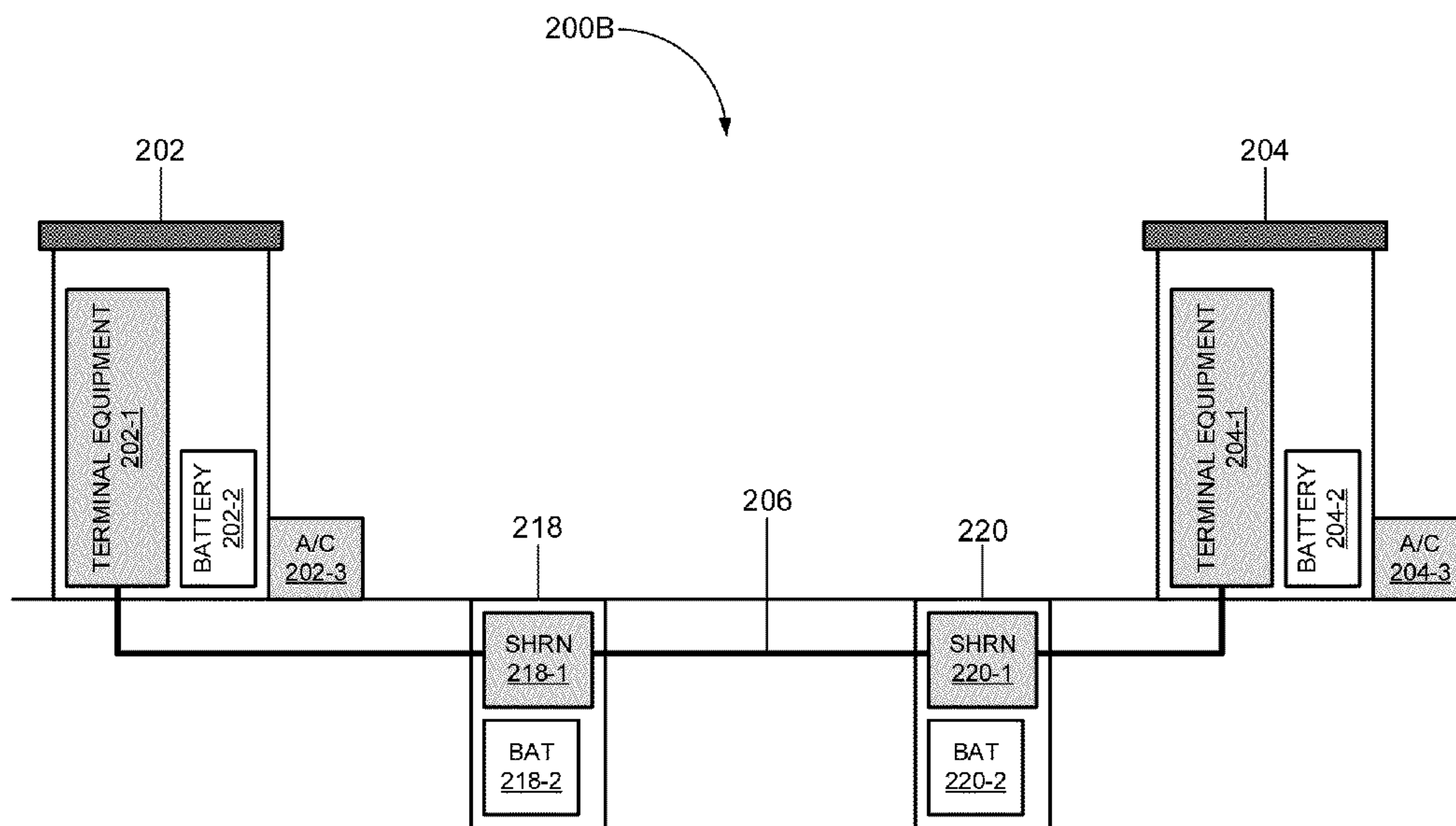


Fig. 2B

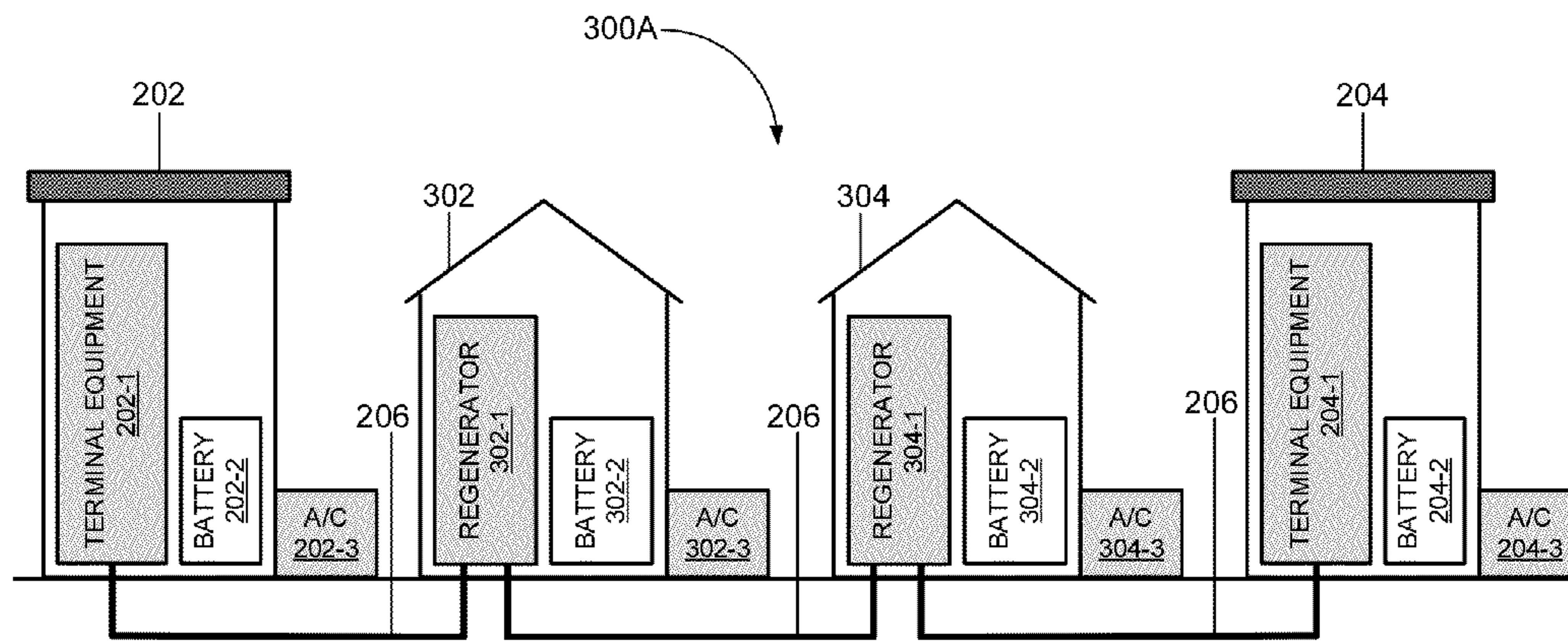


Fig. 3A

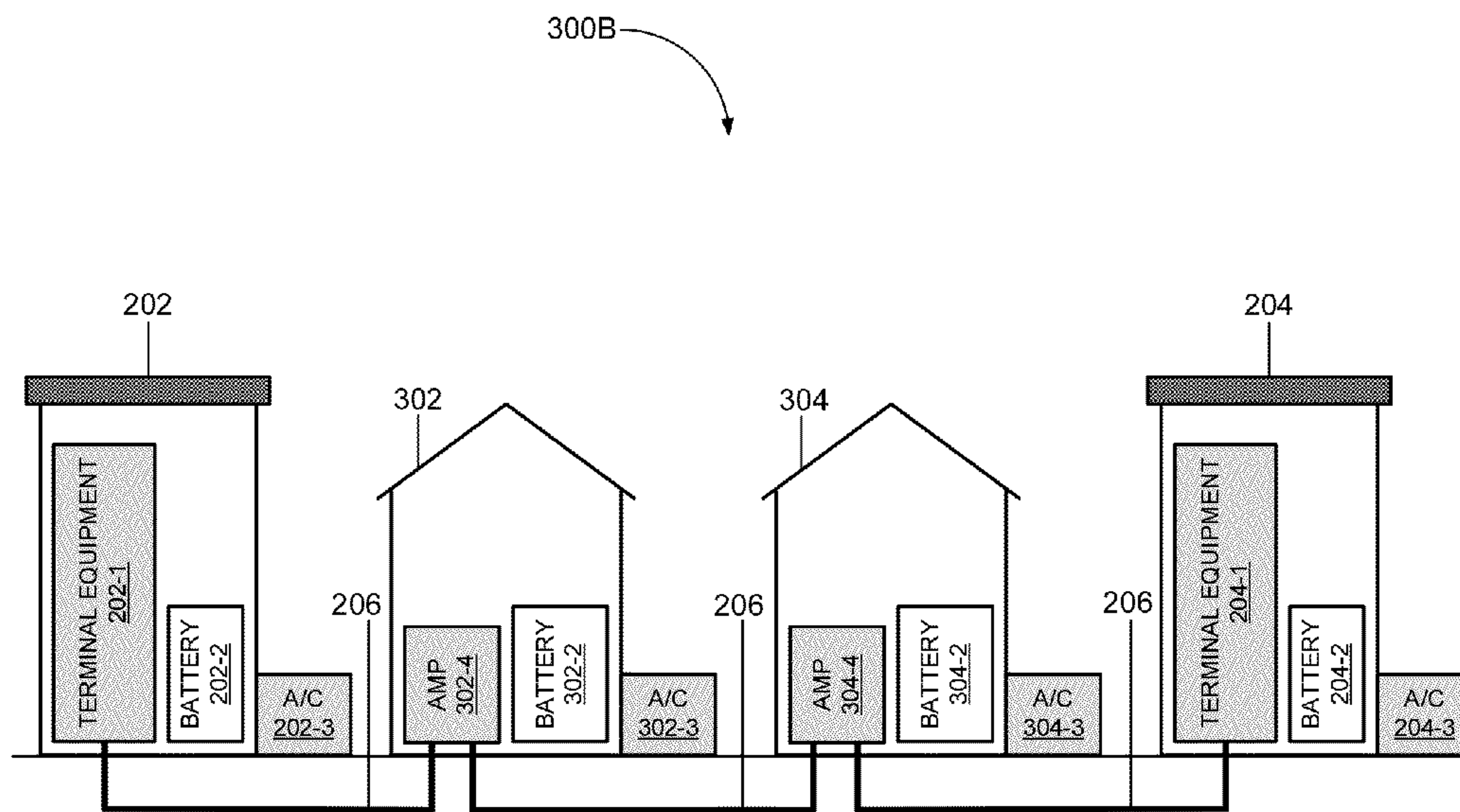


Fig. 3B

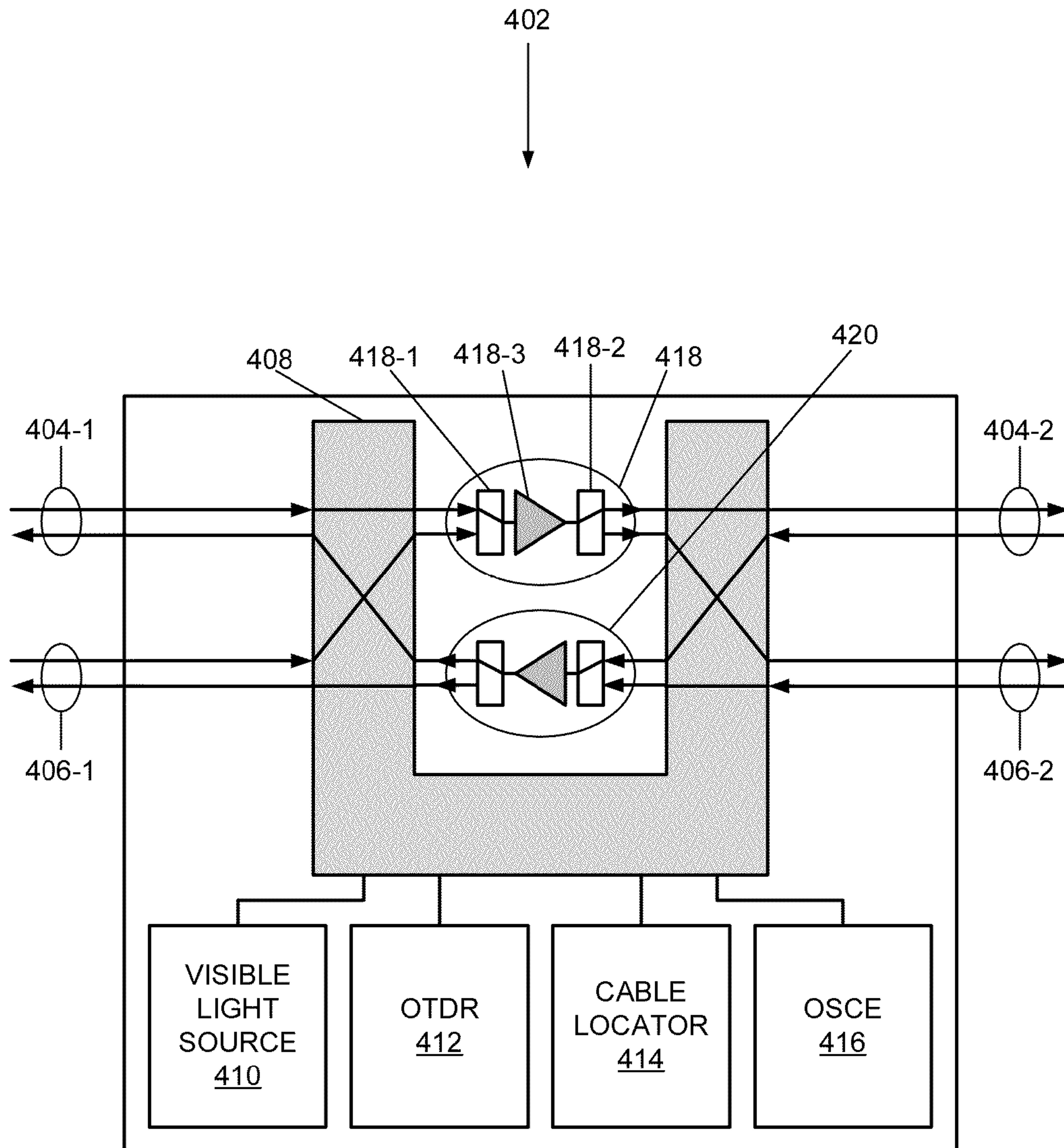


Fig. 4

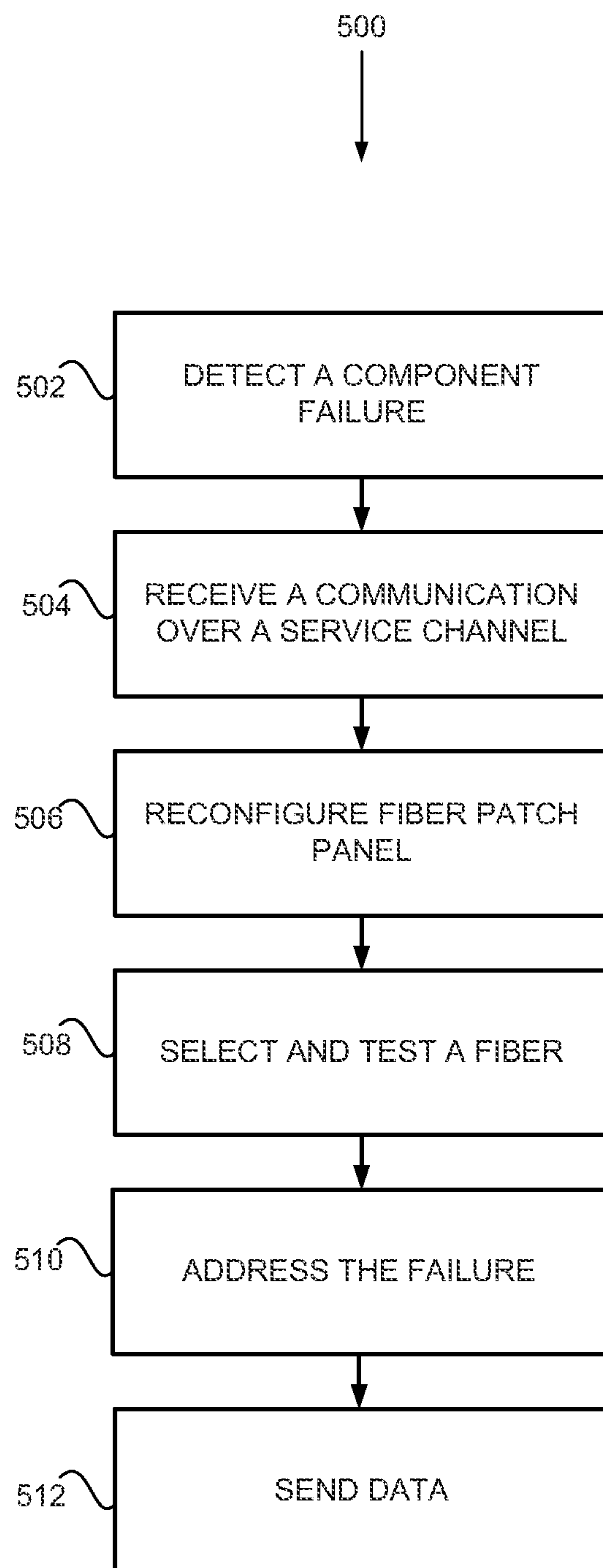


Fig. 5

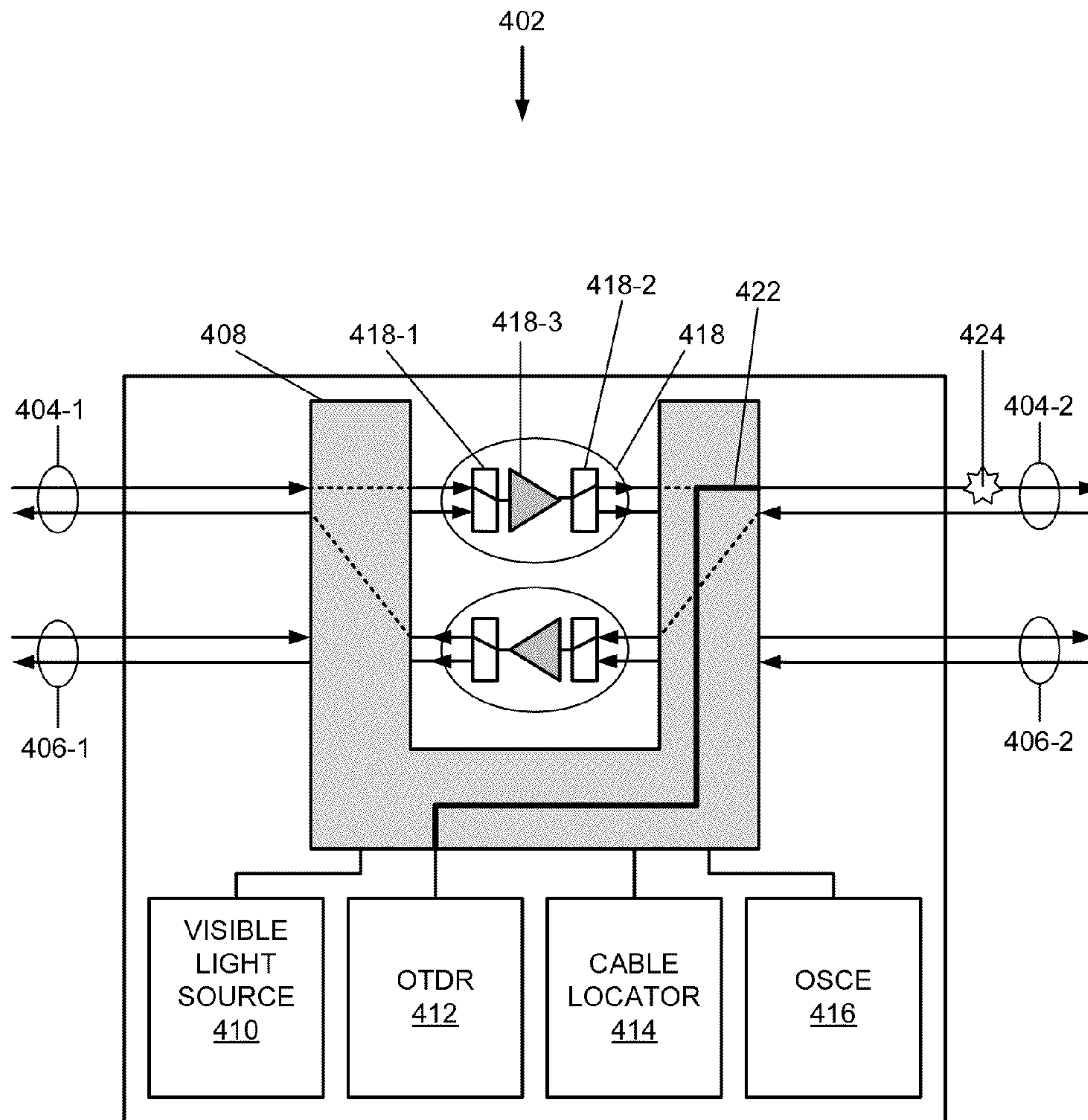


Fig. 6

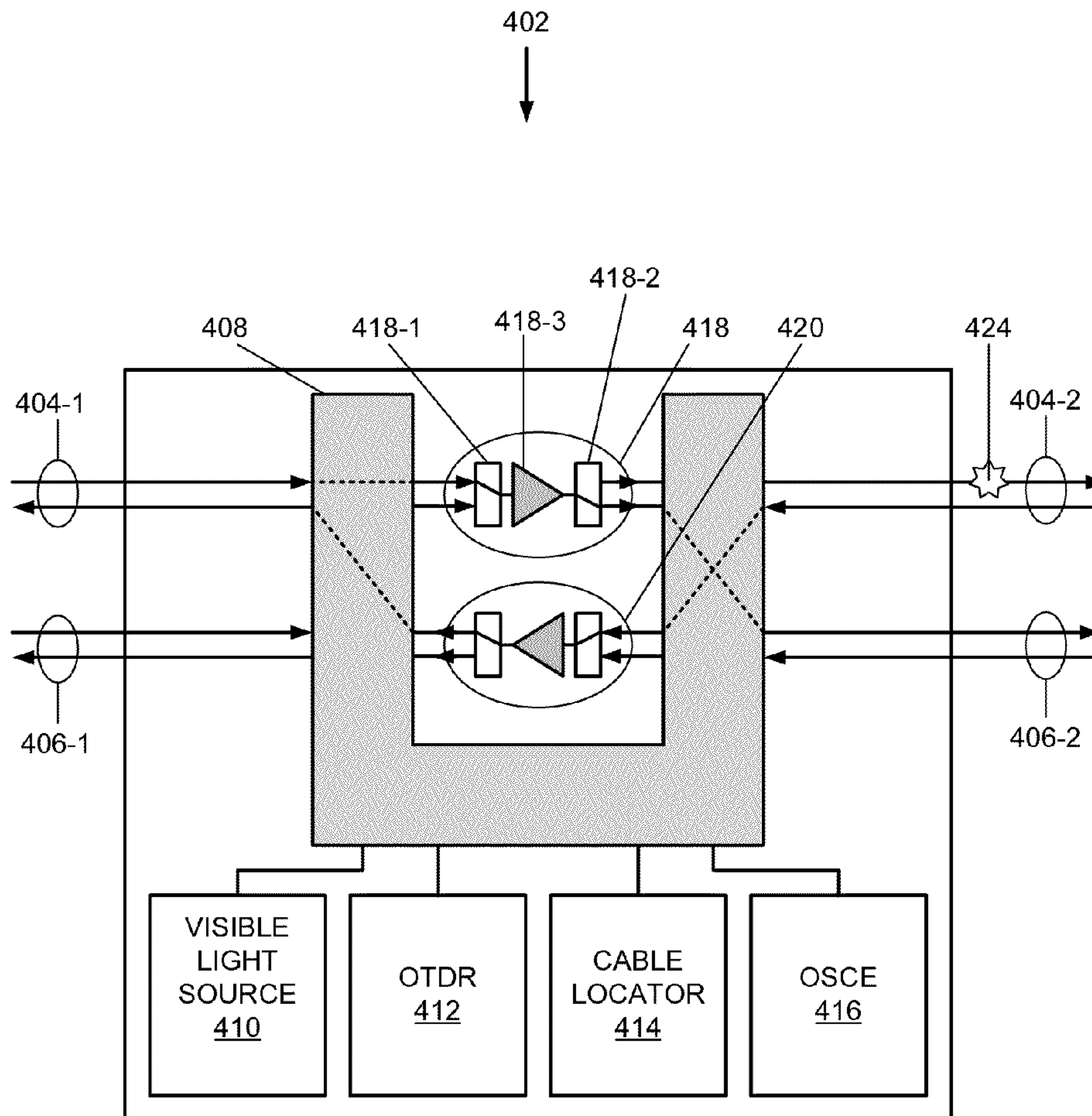


Fig. 7

SELF-HEALING REPEATER NODE

BACKGROUND INFORMATION

Optical amplifiers and regenerators may restore power and shape to degraded optical signals. Optical signals between a central office to a customer premise often pass through either optical amplifiers and/or regenerators, because, as the optical signals travel through a fiber, the signals may attenuate and/or become distorted.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an exemplary optical network in which concepts described herein may be implemented;

FIGS. 2A through 3B are diagrams of an exemplary portion of the optical network of FIG. 1;

FIG. 4 is a diagram of an exemplary self-healing (SH) repeater node of FIGS. 2A and/or 2B;

FIG. 5 is a flow diagram of an exemplary process that is associated with operation of the SH repeater node of FIG. 4; and

FIGS. 6 and 7 illustrate an example of the operation of the SH repeater node of FIG. 4.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

As described below, a self-healing (SH) repeater node may be used instead of an optical regenerator node and/or amplifier node. When a component of the SH repeater node fails (e.g., an optical fiber, an amplifier pump, etc.), the SH repeater node may detect the failure and/or fix the component. For example, if the SH repeater node detects a fault/flare (e.g., a break) in optical fiber, the SH repeater node may allow a network operator to test the broken fiber, identify the location of the fault/flare, and re-route a communication signal from the broken fiber to another fiber. The SH repeater node may perform these operations automatically or in accordance with commands issued from a remote device.

In addition, the SH repeater node may be compact. Typically, a legacy regenerator or amplifier is installed in a large housing to provide convenient access to an engineer, service person, etc. Because the SH repeater node may repair itself, it may not need to provide such access, and consequently, may be placed in a compact container, manhole, hand hole, etc. In addition, because the SH repeater node may be environmentally hardened, it may withstand temperature changes, moisture, wind, radiation, vibrations, etc.

The SH repeater node may integrate many different components (e.g., a test equipment for remote troubleshooting) to lower the failures-in-time (e.g., to less than 5000 failures/billion unit-hours of operating time), and to support, if necessary, local maintenance activity. In addition, the SH repeater node may be energy efficient (e.g., 100 W).

FIG. 1 shows an exemplary optical network 100 in which the concepts described herein may be implemented. As shown, optical network 100 may include metro/regional networks 102 and 104, long haul or ultra-long haul optical lines 106, and edge network 108. Depending on the implementation, optical network 100 may include additional, fewer, or different optical networks and optical lines than those illustrated in FIG. 1. For example, in one implementation, optical network 100 may include additional edge networks and/or

metro/regional networks that are interconnected by Synchronous Optical Network (SONET) rings.

Metro/regional network 102 may include optical fibers and central office hubs that are interconnected by the optical fibers. The optical fibers, which may form the backbone of metro/regional optical network 102, may span approximately 50 to 500 kilometers (km). The central office hubs, one of which is illustrated as central office hub 110, may include sites that house telecommunication equipment, including switches, optical line terminals, etc. In addition to being connected to other central offices, central office hub 110 may provide telecommunication services to subscribers, such as telephone service, access to the Internet, cable television programs, etc., via optical line terminals.

Metro/regional network 104 may include similar components as metro/regional network 102 and may operate similarly. In FIG. 1, metro/regional network 104 is illustrated as including central office hub 112, which may include similar components as central office hub 110 and may operate similarly.

Long haul optical lines 106 may include optical fibers that extend from metro/regional optical network 102 to metro/regional optical network 104. In some implementations, long haul optical lines 106 may span approximately 500 km or more.

Edge network 108 may include optical networks that provide user access to metro/regional optical network 104. As shown in FIG. 1, edge network 108 may include access points 114 (e.g., office buildings, residential area, etc.) via which end customers may obtain communication services from central office hub 112.

FIG. 2A is a diagram of an exemplary portion 200A of optical network 100. Portion 200A may be part of metro/regional network 102, metro/regional network 104, or long haul optical lines 106. As shown, portion 200A may include central office hubs 202 and 204, optical fibers 206, and node facilities 208 and 210. Depending on the implementation, portion 200A may include additional, fewer, or different components than those illustrated in FIG. 2A (e.g., additional node facilities).

Central office hub 202 or central office hub 204 may include telecommunication equipment, including switches, optical line terminals, etc., and may provide telecommunication services to subscribers, such as telephone service, access to the Internet, cable television programs, etc., via optical line terminals.

For example, in FIG. 2A, central office hub 202 may include terminal equipment 202-1, a battery 202-2, and an air-conditioning unit 202-3. Terminal equipment 202-1 may include components for optical telecommunications (e.g., optical switches, optical line terminals, etc.). Battery 202-2 (or a power adaptor) may provide power to terminal equipment 202-1. Air conditioning unit 202-3 may provide a stable temperature for terminal equipment 202-1.

Optical fibers 206 may connect central office hubs 202 and 204, and may convey optical signals from/to central office hub 202 to/from central office hub 204. As shown, optical fibers 206 pass through node facilities 208 and 210.

Node facility 208 or 210 may include SH repeater nodes 208-1 or 210-1 to amplify and/or regenerate an optical signal that arrives from central office hub 202 or 204 via optical fibers 206 and transmit the amplified signal toward central office hub 204 or 202. As shown in FIG. 2A, node facilities 208 and 210 may include enclosures (e.g., cabinets) in which SH repeater nodes 208-1 and 210-1, respectively, may be housed. SH repeater nodes 208-1 and 210-1 may be powered by, respectively, batteries 208-2 and 210-2 that are included in

node facilities **208** and **210**. In a different implementation, node facilities **208** and **210** may include different components (e.g., a power adaptor).

FIG. 2B is a diagram of another exemplary portion **200B** of optical network **100**. Portion **200B** may be part of metro/ regional network **102**, metro/regional network **104**, or long haul optical lines **106**. As shown, portion **200B** may include central office hubs **202** and **204**, optical fibers **206**, and node facilities **218** and **220**. Depending on the implementation, portion **200B** may include additional, fewer, or different components than those illustrated in FIG. 2B (e.g., additional node facilities).

Node facility **218** and node facility **220** may include components (e.g., SH repeater node **218-1** and battery **218-2**) that correspond to components of node facility **208** (e.g., SH repeater node **208-1** and battery **208-2**) and node facility **210**, respectively. In addition, node facilities **218** and **220** may operate similarly as node facilities **208** and **210**.

In contrast to node facilities **208** and **210**, however, node facilities **218** and **220** may include enclosures that are under- or in-ground (e.g., man-hole, hand-hole, etc.). The enclosures may house SH repeater nodes **218-1** and **220-1** and batteries **218-2** and **220-2**.

In the exemplary embodiments of FIGS. 2A and 2B, the enclosures in node facilities **208**, **210**, **218**, and **220** may be constructed just large enough to house SH repeater nodes **208-1**, **210-1**, **218-1** and **220-1**, and/or batteries **208-2**, **210-2**, **218-2**, and **220-2**. Such implementations may save space and reduce cost that is associated with a larger housing. SH repeater nodes **208-1**, **210-1**, **218-1**, and **220-1** may be environmentally hardened, and may be capable of withstanding large swings in temperature, moisture, vibration, etc.

FIG. 3A is a diagram of yet another exemplary portion **300A** of optical network **100**. Portion **300A** may be part of metro/regional network **102**, metro/regional network **104**, or long haul optical lines **106**. As shown, portion **300A** may include central office hubs **202** and **204**, optical fibers **206**, and node facilities **302** and **304**. Depending on the implementation, portion **300A** may include additional node facilities that are approximately 30 to 80 km apart.

Node facility **302** and node facility **304** may include legacy regenerator nodes **302-1** and **304-1** and batteries **302-2** and **304-2** that correspond to components **208-1**, **210-1**, **208-2**, and **210-2** of node facilities **208** and **210**, respectively. In addition, node facilities **302** and **304** may include air conditioning units **302-3** and **304-3**, respectively. Air conditioning units **302-3** and **304-3** may provide stable environments (e.g., constant temperature) for node facilities **302** and **304**.

In contrast to SH repeater nodes **208-1** and **210-1**, legacy regenerator nodes **302-1** and **304-1** may be large, and therefore, may occupy more space. Furthermore, legacy regenerator nodes **302-1** and **302-2** may not be environmentally hardened, and may require the inclusion of air conditioning units **302-3** and **304-3**, resulting in increased power consumption.

In implementations that are similar to the one shown in FIG. 3A, but with more node facilities, optical signal may be regenerated at each of the node facilities, which may be 30-80 km apart. With advances in modern optical communication technology, however, the optical signal may only need to be boosted in power once every ~20-30 km, and regenerated once every ~1,000 km. Consequently, many of regenerator facilities, such as, for example, regenerator facility **302**, that are 30 to 80 km apart, may be replaced with node facilities that include optical amplifiers or SH repeater nodes instead of legacy regenerator nodes.

FIG. 3B is a diagram of portion **300B** of optical network **100** in which regenerator nodes are replaced with amplifiers.

As shown in FIG. 3B, portion **300B** may include similar components as portion **300A** in FIG. 3A. However, in contrast to FIG. 3A, node facilities **302** and **304** in FIG. 3B may include amplifiers **302-4** and **304-4**, respectively, instead of legacy regenerator nodes **302-1** and **304-1** in FIG. 3A.

Because amplifiers **302-4** and **304-4** may be small (e.g., size of notebook) relative to legacy regenerator nodes **302-1** and **304-1**, it may be possible to decrease the size of the housing for node facilities **302** and **304** by using amplifiers **302-4** and **304-4** in place of legacy regenerator nodes **302-1** and **304-1**.

In addition, SH repeater nodes **208-1** and **210-1** (FIG. 2A), which may include optical amplifiers, may also be used instead of legacy regenerator nodes **302-1** and **304-1** in node facilities **302** and **304** to reduce the size of the housing. In such an implementation, because SH repeater nodes **208-1** and **210-1** may be environmentally hardened, air conditioning units **302-3** and **304-3** can be eliminated.

FIG. 4 is a diagram of an exemplary SH repeater node **402**. SH repeater node **402** may represent any of SH repeater nodes **208-1**, **210-1**, **218-1**, and **220-1**. As shown, SH repeater node **402** may include primary fibers **404-1** and **404-2**, backup fibers **406-1** and **406-2**, automated fiber patch panel **408**, visible light source **410**, optical time domain reflectometer (OTDR) **412**, cable locator **414**, optical service channel (OSC) equipment **416**, and amplifier modules **418** and **420**. Depending on the implementation, SH repeater node **402** may include additional, fewer, or different components than those illustrated in FIG. 4. For example, in one implementation, SH repeater node **402** may include a fiber optics switch (FOS).

Primary fibers **404-1** and **404-2** may carry optical signals to/from remote devices. Each of primary fibers **404-1** and **404-2** may include a pair of optical fibers. Backup fibers **406-1** and **406-2** may carry optical signals when one or both of the pairs of optical fibers of primary fibers **404-1** and/or **404-2** fail.

Each of fibers in primary fibers **404-1** and **404-2** and backup fibers **406-1** and **406-2** may provide a large number of individual data/service channels (e.g., **80** channels) via which data may be transmitted. In one implementation, the optical fibers may carry troubleshooting and/or error messages in a service channel to/from a remote device, without interfering with other messages on data channels on the same optical fiber.

In some implementations, primary fibers **404-1** and **404-2** and backup fibers **406-1** and **406-2** may carry optical signals that are wavelength division multiplexed (WDM). In WDM, multiple optical carrier signals are transmitted on a single optical fiber by using different wavelengths of laser light or electromagnetic radiation. In some implementations, optical signals may be dense wave division multiplexed (DWDM). DWDM uses the C band (i.e., frequencies between 1530 and 1565 nanometers (nm)) and/or L band (i.e., wavelengths between 1565 and 1625 nm).

Automated fiber patch panel **408** may include optical ports to which different components of SH repeater node **402** (e.g., primary fibers **404-1**) may be attached and may send/or receive optical signals. In addition, depending on the configuration, automated fiber patch panel **408** may optically couple two of the ports, such that an optical signal received at one of the coupled ports is routed to the other.

For example, in FIG. 4, automated fiber patch panel **408** may couple a port (not shown in FIG. 4) that is connected to one of primary fibers **404-1** to a port (not shown in FIG. 4) connected to amplifier module **418**. Accordingly, an optical signal may travel from one of primary fibers **404-1** to amplifier module **418** via automated fiber patch panel **408**.

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Visible light source **410** may include a source of light that may be used to locate a particular optical fiber. A field engineer may direct visible light source **410** into a selected optical fiber, for example, to physically see which optical fiber end emits the light.

OTDR **412** may include instruments to measure parameters that are associated with an optical fiber. In one implementation, OTDR **412** may transmit optical pulses into an end of an optical fiber, and monitor, at the same end, pulses that are reflected from various points on the fiber where the index of refraction changes. OTDR **412** may detect and/or record the strength of reflected pulses and times at which the reflected pulses are received. Such information may be used to characterize the fiber (e.g., locate breaks in the fiber).

Cable locator **414** may emit electrical signals (e.g., encoded physical coordinates) to allow a field engineer to locate SH repeater node **402** by using a receiver/decoder.

OSC equipment **416** may send/receive information over service channels, via primary fibers **404-1** or **404-2** and/or backup fibers **406-1** or **406-2**. For example, when OSC equipment **416** detects a break in primary fibers **404-2**, OSC equipment **416** may send data that is provided by OTDR **412** to a remote device. In addition, OSC equipment **416** may receive commands/requests from the remote device to reconfigure repeater node **402** or to perform tests to isolate a fault/flaw on an optical fiber.

Amplifier module **418** and **420** may amplify an optical signal. For example, amplifier module **418** may amplify an optical signal that is received from one of primary fibers **404-1** and output the amplified signal to one of primary fibers **404-2** via automated fiber patch panel **408**.

As further shown in FIG. 4, amplifier module **418** may include switches **418-1** and **418-2** and an optical amplifier **418-3**. Depending on the implementation, amplifier module **418** may include additional, fewer, or different components than those illustrated in FIG. 4.

Switch **418-1** may select, depending on its setting or configuration, an input signal from a pair of optical fibers that include one of primary fibers **404-1** and one of backup fibers **406-1**, and route the selected signal to optical amplifier **418-3**. For example, in FIG. 4, when switch **418-1** is in the “up” configuration, switch **418-1** may route the optical signal from primary fibers **404-1** to optical amplifier **418-3**.

Switch **418-2** may output, depending on its setting of configuration, optical signal from optical amplifier **418-3** to one of a pair of optical fibers that include one of primary fibers **404-2** and one of backup fibers **406-2**. For example, in FIG. 4, when switch **418-2** is in the “up” configuration, switch **418-2** may route the optical signal from optical amplifier **418-3** to primary fibers **404-2**.

Optical amplifier **418-3** may amplify optical signal received from switch **418-1** and output the amplified signal to switch **418-2**. Optical amplifier **418-3** may include a primary laser pump and a backup laser pump. The backup laser pump may operate instead of the primary laser pump when the primary laser pump fails. Optical amplifier **418-3** may be smaller than legacy regenerators, such as a regenerator in regenerator node **302-1**. In a different implementation, SH repeater node may include a compact, optical regenerator instead of optical amplifier **418-3**.

Amplifier module **420** may include similar components as amplifier module **418** and may operate similarly.

Although not illustrated in FIG. 4, depending on the implementation, repeater node **402** may include additional circuits, one or more processors, logic, or mechanisms to control switches in amplifier module **418** and/or other components, such as automated fiber patch panel **408**, visible light source

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410, OTDR **412**, cable locator **414**, and/or OSC equipment **416**, etc. For example, in one implementation, OSC equipment **416** may include a processor for communicating with a remote device over a service channel (e.g., receive a command to conduct a test using OTDR **412**), for monitoring and/or controlling OTDR **412** (e.g., obtain measurement of magnitude of reflected optical pulses), for reconfiguring switch settings for switches **418-1** and **418-2**), and/or for performing other functions (e.g., report the failure of a primary laser pump, activating the backup pump, etc.). In a different implementation, SH repeater node **402** may include such a processor or control circuit as a separate component. The component may configure automated fiber patch panel **408**, to cause automated fiber patch panel **408** to couple two specific ports.

FIG. 5 is a flow diagram of an exemplary process **500** that is associated with operation of SH repeater node **402**. Although process **500** is depicted as starting at block **502**, in different embodiments, process **500** may start at other blocks. In addition, depending on situations or the configuration of SH repeater node **402**, each block may be performed independently of other blocks.

SH repeater node **402** may detect a component failure (block **502**). In one example, SH repeater node **402** may detect a failure of the primary laser pump in optical amplifier **418-3**. In another example, SH repeater node **402** may detect a break in primary fibers **404-2** by sending test pulses at one end of primary fibers **404-2**, and monitoring reflected pulses at the same end.

When SH repeater node **402** detects the failure, SH repeater node **402** may send a message to a remote device over a service channel (block **502**). For example, assume that SH repeater node **402** has tested primary fibers **404-2** and detected a break. SH repeater node **402** may send one or more messages that describe the test (e.g., magnitudes of transmitted pulses, magnitudes of reflected pulses, time differences between the transmitted and reflected pulses, etc.) to the remote device. In another example, SH repeater node **402** may send a message to the remote device about a failure of the primary laser pump in optical amplifier **418-3**.

SH repeater node **402** may receive a communication over a service channel (block **504**). For example, SH repeater node **402** may receive a command from a remote device. The command may instruct SH repeater node **402** to address the failure (e.g., activate a backup laser pump, reroute an optical signal to backup fibers **406-2**, etc.), test specific fibers (e.g., primary fibers **404-1**, backup fibers **406-1**, etc.), to reconfigure automatic fiber patch panel **408**, to provide information (e.g., a result of testing a fiber) to the remote device, and/or to perform any other functions that are associated with changing the configuration of SH repeater node **402**.

SH repeater node **402** may reconfigure automated fiber patch panel **408** (block **506**). For example, assume that SH repeater node **402** receives a command to test primary fibers **404-2**. In such an instance, SH repeater node **402** may cause automated fiber patch-panel **408** to couple a port connected to OTDR **412** and a port connected to primary fibers **404-2**. This may provide an optical path between OTDR **412** and primary fibers **404-2**.

SH repeater node **402** may select and test an optical fiber (block **508**). For example, assume that SH repeater node **402** receives a command from a remote device to test primary fibers **404-1**. In such an instance, SH repeater node **402** may cause automated fiber patch panel **408** to provide an optical path from OTDR **412** to primary fibers **404-1**, and direct OTDR **412** to perform a test on primary fibers **404-1**. Consequently, OTDR **412** may send a series of pulses at one end of

primary fibers **404-1** and monitor reflected pulses at the same end. After performing the test, OTDR **412** may provide a test result (e.g., data) to OSC equipment **416**, which may send the test result to the remote device over primary fibers **404-1**.

SH repeater node **402** may address the component failure (block **510**). For example, SH repeater node **402** may activate the backup laser pump in amplifier **418-3** to operate in place of the failed primary laser pump in amplifier **418-3**. In another example, referring to FIG. **4**, assume one of primary fibers **404-1** that carries an incoming optical signal fails. Upon detecting the failure, SH repeater node **402** may reconfigure switch **418-1**, such that amplifier **418-3** no longer receives optical signals from primary fibers **404-1**, but from backup fibers **406-1**. Similarly, SH repeater node **402** may modify configurations of other switches (e.g., switch **418-2**, switches in amplifier module **420**, etc.) to change other optical paths through SH repeater node **402**.

SH repeater node **402** may send data to a remote device (block **512**). Depending on the circumstance, SH repeater node **402** may send data (e.g., data from testing optical fibers, information about a failed pump, etc.) in response to a request from the remote device or as a result of performing a test.

The following example, in conjunction with FIGS. **6** and **7**, illustrates processes involved in operation of SH repeater node **402** in accordance with implementations described above.

In the example, as illustrated in FIG. **6**, assume that one of primary fibers **404-2** includes a break **424**. Also assume that a user at a remote device decides to perform a diagnostic test on SH repeater node **402**. In FIG. **6**, optical paths through automated fiber patch **408** are shown in dotted lines. As explained above, each optical path may couple two optical ports of automated fiber patch **408**.

The user sends a command to SH repeater node **402** from a remote device. Via OSC equipment **416**, SH repeater node **402** receives the command over an un-broken optical fiber of primary fibers **404-2**. The command instructs SH repeater node **402** to conduct a diagnostic test on primary fibers **404-2**.

Upon receiving the command, SH repeater node **402** reconfigures automated fiber patch panel **408** so that OTDR **412** is coupled to primary fibers **404-2** via an optical path, which is shown in FIG. **6** as optical path **422**. Subsequently, OTDR **412** sends optical pulses to one of primary fibers **404-2**, and monitors reflected optical signals. SH repeater node **402** collects data from the OTDR **412**, and sends the data to the remote device over a service channel via the unbroken fiber of primary fibers **404-2**.

From examining the data, the user determines that there is break **424** on primary fibers **404-1** and decides to deploy backup fibers **406-2**. The user sends a command over the service channel to reconfigure amplifier module **418**.

Upon receiving the command, SH repeater node **402** reconfigures switch **418-2** in amplifier module **418** to reroute the optical signal from the output of optical amplifier **418-3** to one of backup fibers **406-2**. Optical paths that result from the reconfiguration are shown in FIG. **7** as dotted lines.

Later, when a field engineer visits a node facility that houses SH repeater node **402** for maintenance, the field engineer activates cable locator **414**, which transmits a homing signal. Upon locating the node facility, the field engineer detaches and examines primary and backup fibers **404-1**, **404-2**, **406-1**, and **406-2**, and re-attaches them to correct ports on automated fiber patch panel **408**. In addition, the field engineer replaces the broken optical fiber.

The above example illustrates how SH repeater node **402** may operate. More generally, as described prior to the example, SH repeater node **402** may be used instead of an

optical regenerator node and/or amplifier node. When a component of SH repeater node **402** fails (e.g., an optical fiber, an amplifier pump, etc.), SH repeater node **402** may detect the failure and/or fix the component. For example, if an optical fiber breaks, SH repeater node **402** may detect the break, may allow a network operator to test the broken fiber, may identify the location of the break, and may route optical signal that travels on the fiber to another fiber. SH repeater node **402** may perform these operations automatically or in accordance with commands issued from a remote device.

In addition, SH repeater node **402** may be compact. Typically, a legacy regenerator or amplifier is installed in a large housing to provide convenient access to an engineer, service person, etc. Because SH repeater node **402** is capable of repairing itself, it may not need to provide such access, and consequently, may be placed in a compact container, man-hole, hand hole, etc. In addition, because SH repeater node **402** is environmentally hardened, it may withstand temperature changes, moisture, wind, radiation, vibration, etc.

SH repeater node **402** may integrate many different components (e.g., a test equipment for remote troubleshooting) to lower the failures-in-time, and to support, if necessary, local maintenance activity. In addition, SH repeater node **402** may be energy efficient.

In this specification, various preferred embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope of the invention as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

For example, while a series of blocks have been described with regard to the process illustrated in FIG. **5**, the order of the blocks may be modified in other implementations. In addition, non-dependent blocks may represent blocks that can be performed in parallel.

No element, block, or instruction used in the present application should be construed as critical or essential to the implementations described herein unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A device comprising:

a component for configuring optical paths between ports, comprising:

a first pair of optical ports connected to a first pair of optical fibers, and

a second pair of optical ports connected to a second pair of optical fibers;

a first switch configured to output one of two optical signals received by the first pair of optical ports from the first pair of optical fibers;

a repeater to including one of:

an optical regenerator for reshaping the outputted optical signal, or

an optical amplifier to boost power of the outputted optical signal, wherein the optical amplifier includes:

a primary amplifier pump; and

a backup amplifier pump;

an optical service channel to send one or more messages to a remote device over one of the first pair of optical fibers, the one or more messages indicative of activation of the backup amplifier pump responsive to a failure of the primary amplifier pump; and

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a second switch configured to direct the reshaped or amplified signal to one of the second pair of optical ports.

2. The device of claim 1, wherein the component includes one of:

- a fiber optic switch; or
- an automated fiber patch panel.

3. The device of claim 1, wherein the device includes a housing that includes the component, the first switch, the repeater, and the second switch.

4. The device of claim 1, wherein the first switch includes a 1×2 optical switch and the second switch includes a 1×2 optical switch.

5. The device of claim 1, wherein the device is environmentally hardened.

6. A device comprising:

a component for configuring optical paths between ports, comprising:

- a first pair of optical ports connected to a first pair of optical fibers, and
- a second pair of optical ports connected to a second pair of optical fibers;

a first switch configured to output one of two optical signals received by the first pair of optical ports from the first pair of optical fibers;

a repeater to reshape or amplify the outputted optical signal;

a second switch configured to direct the reshaped or amplified signal to one of the second pair of optical ports;

an optical time domain reflectometer for detecting a fault in an optical fiber;

an optical service channel equipment to communicate with a remote device; and a processor configured to:

receive a command from the remote device via the optical service channel equipment, and

cause, based on the command, the optical time domain reflectometer to test for a fault in one of the first pair of optical fibers.

7. The device of claim 6, wherein the processor is further configured to:

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cause the component to change the optical paths between the ports.

8. The device of claim 6, wherein the processor is further configured to:

cause the first switch to output another of the two optical signals received by the first pair of optical ports.

9. The device of claim 6, wherein the processor is further configured to:

redirect the reshaped or amplified signal to another of the second pair of the optical ports when an optical fiber attached to the one of the second pair of optical ports includes a fault.

10. A method comprising:

outputting, at a first switch, one of two optical signals received at a first pair of optical ports connected to the first pair of optical fibers via a first pair of optical fibers;

amplifying, at an optical amplifier, power of the outputted optical signal, wherein the optical amplifier includes a primary amplifier pump and a backup amplifier pump;

sending, by an optical service channel, one or more messages to a remote device over one of the first pair of optical fibers, wherein the one or more messages are indicative of activation of the backup amplifier pump responsive to a failure of the primary amplifier pump;

and

directing, by a second switch, the amplified signal to one of a second pair of optical ports connected to a second pair of optical fibers.

11. The method of claim 10, further comprising:

receiving, via an optical service channel equipment, a command from the remote device, and

causing, based on the command, an optical time domain reflectometer to test for a fault in one of the second pair of optical fibers.

12. The method of claim 11, further comprising:

redirecting, at the second switch, the amplified signal to another of the second pair of the optical ports responsive to the optical time domain reflectometer detecting the fault.

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